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ABSTRACT

A research project identified and prototyped critical elements of an automated development system for interactive courseware (ICW) for job training. The prototype system incorporated a multimedia database that contained all completed, planned, and partially completed media elements. A web-based approach was taken to overcome the problems of platform dependence. The system consisted of the following elements: an electronic storyboard that allowed designers to enter data elements as they performed preproduction design and development activities; a media production tool that provided access to and reports from the multimedia database; and a project management tool that provided information to ICW development managers. The system definition involved the following steps: (1) capture the concept of operations; (2) document a concise set of requirements; (3) develop a preliminary database architecture; (4) select appropriate system hardware; (5) design the network architecture; and (6) select commercial off-the-shelf software. Preliminary use of the system identified additional features that would make the system more useful for ICW development such as a distributed media repository to replace the current database structure; a full-text search capability; an encryption capability; and teaming tools. A comparison of the time required to develop one hour of ICW using the automated approach and the traditional approach showed the time was reduced by approximately 30 percent when the automated system was used. (YLB)

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AN APPROACH TO AUTOMATING DEVELOPMENT OF INTERACTIVE COURSEWARE

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ABSTRACT

Since the early 1970s, the computer-based training industry has grown to the point where most American government agencies and private organizations, and a significant number of international organizations, implement some type of interactive courseware (ICW) in their training programs. Some organizations rely solely on ICW to deliver training, while others combine ICW with other delivery methods, such as classroom instruction, on-the-job training, and simulator-based training.

Historically, the process of developing ICW has been viewed as complicated and risky. There are as many documented cases of cost overruns and poor-quality products as there are successful programs. However, even with the risks and high costs associated with ICW, it has emerged as the most popular training delivery system within the last 30 years. With more powerful computing technologies now available at lower cost, and the emergence of digitial multimedia, the popularity of ICW is increasing.

It has long been accepted by those who develop multimedia ICW that it is necessary to automate critical aspects of the ICW development process. There is less agreement on which aspects should be automated and the approach that should be taken to automation. This paper will describe a research project in which critical elements of an automated development system were identified and prototyped.

The prototype system incorporates a multimedia database which contains all completed, planned, and partially completed media elements. A Web-based approach was taken to overcome the problems of platform dependence. The system consists of an *electronic storyboard tool* which allows designers to enter data elements as they perform preproduction design and development activities; *a media production tool* which provides access to and reports from the multimedia database; and a *project management tool* which provides information to ICW development managers.

A comparison of ICW development using the traditional approach and the automated approach with the prototype system was performed. The result was a reduction in labor hours of approximately 30 percent using the automated approach.

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BACKGROUND: THE NEED FOR AN AUTOMATED SYSTEM FOR INTERACTIVE COURSEWARE DEVELOPMENT

Interactive courseware (ICW) is an instructional medium in which computer hardware and software are used to deliver instruction and test students on their ability to understand content and perform tasks. Due to the rapid development of computer technology, particularly in multimedia such as digital audio, video, and graphics, ICW has become the preferred instructional delivery system for many training programs. The Department of Defense has embraced ICW as a primary instructional delivery system for new weapons systems, and many older classroom-based systems are being converted to ICW. It has long been accepted by those who have dealt with the complexity of developing multimedia ICW that it is necessary to find a way to automate the most critical aspects of the ICW development process. The following paragraphs describe some of the problems inherent in the traditional method of developing ICW.

Development and Review of Storyboards

Storyboards generally contain descriptions of the text and visuals, programming notes, text for audio narration, correct student responses, and feedback in response to student actions. Development of paper-based storyboards has always been a time-consuming process. Each time a revision is made, a complete set of storyboards are usually reprinted and provided to the reviewers. Careful review of storyboards by the subject matter experts and clients is necessary before money is expended to develop the media and program the ICW. This is a major weakness in the process since many clients find it difficult or impossible to visualize the "look and feel" of a lesson from paper-based storyboards, especially when 3D animation or motion video is described. Often it is difficult to convince clients to provide careful technical review of paper-based storyboards. Only when the ICW is programmed and the clients can sit at the computer and see a lesson, do they carefully review the content for technical accuracy. It is at this point, after programming has been done, that changes can be expensive.

Storage and Retrieval of Media Elements

Traditionally, media elements (photographs, video segments, 2D and 3D graphics, audio) are digitized and inserted into the ICW as the final step in the process. When media elements are completed for one lesson, they are not easily accessed by other members of the development team. For some projects, a large number of visual media elements exist at the start of a project, such as one where ICW is being developed for an existing aircraft system. However, instructional designers do not have time to manually search through boxes of photographs and schematics to find the one photograph that might work on the storyboard frame they are designing.

Management of the Development Process

Managers frequently ask designers to provide data on "percentage complete." Calculating this number is a tedious and inexact science, especially on large ICW projects where hundreds of ICW lessons are being developed. A method is needed to easily determine how much work has actually been completed, such as how many storyboards have been designed and reviewed by subject matter experts, how many media elements have been produced and digitized, and how many lessons have been reviewed.

DESCRIPTION OF THE RESEARCH APPROACH

Our experience has shown that the aspects of the ICW development process that would most benefit from automation are development and review of storyboards, storage and retrieval of media elements (graphics, audio, animation, video segments), and management of the development process. We believe that a system for automating the ICW development process should provide the

ability to develop high-quality ICW with fewer development hours and less experienced personnel, and the ability to produce an improved product by facilitating early and clear communication between all persons involved in the design and development of the ICW. Further, we believe that this system should facilitate improved management and production of courseware by providing communication and data-sharing tools to project managers, designers, clients, subject matter experts, and other production support staff such as photographers, video production teams, and narrators.

Research was needed to determine whether an automated system could be built which would provide these capabilities. Our research effort consisted of defining the system and building a prototype. We determined that the most important feature of this prototype system would be a multimedia database for storage and retrieval of all types of media elements. This multimedia database would need interfaces for various users (members of the ICW development team) to enter and extract information. A Web-based approach was selected to overcome problems related to platform dependence. The system uses standard Internet protocols. Users need only a standard Internet Web browser such as Netscape Navigator or Microsoft Internet Explorer. The system will support users with Windows, Windows 95, Windows NT, OS/2, Macintosh, or UNIX operating systems.

DESCRIPTION OF THE PROTOTYPE SYSTEM

The system consists of an *electronic storyboard tool*, a *media production tool*, and a *project management tool* which are "front ends" to a multimedia database.

The *electronic storyboard tool* allows designers to specify media elements and instructional flow, browse a database to find existing media elements, and receive review comments for updates. The *electronic storyboard tool* also provides reviewers, including clients, subject matter experts, and managers a means to review and approve lessons electronically at varying stages of completeness. In the final review, they would be able to see or hear the media elements related to each storyboard frame.

The *media production tool* provides reports to be used by those who develop media elements (videographers, graphic artists, animators, photographers, narrators) which would replace manually developed shot lists, narrative scripts, etc. *The media production tool* provides an interface for entering digitized audio and video elements into the system, as well as information such as key words, to help others find the media elements after they have been entered into the database.

The *project management tool* takes input from the storyboard and media production tools and provides reports to managers to help them determine project status.

HOW THE ICW TEAM MEMBERS USE THE AUTOMATED SYSTEM

The easiest way to understand the concept of the automated system is from the perspective of the various members of the development team: instructional designers, subject matter experts, media producers (videographers, graphic artists, photographers, programmers/software designers, narrators), media database producers, managers, and clients. Figure 1 illustrates how the ICW team members use the system.

ICW Designer

The ICW designer uses the system to create a structure for the ICW consisting of courses, units, and lessons. For each lesson, the designer completes as many storyboard frames as necessary. For each frame, the designer enters visuals, audio, text, programming notes, and correct responses. Visuals may include 2D and 3D graphics, still photos, animation, and video segments (digitized).

The designer can enter visuals and audio into the storyboard in the following ways:

- "Request" media elements (video segments, graphics, audio narration) by entering descriptions of audio and visual elements. These "requests" are turned into shot lists, narrative scripts, etc., for the media production staff. The designer can also make rough drawings of visual elements using an electronic drawing pad, or scan in pictures similar to those desired. Once the media elements are produced and digitized, they can be reviewed on the storyboard page.

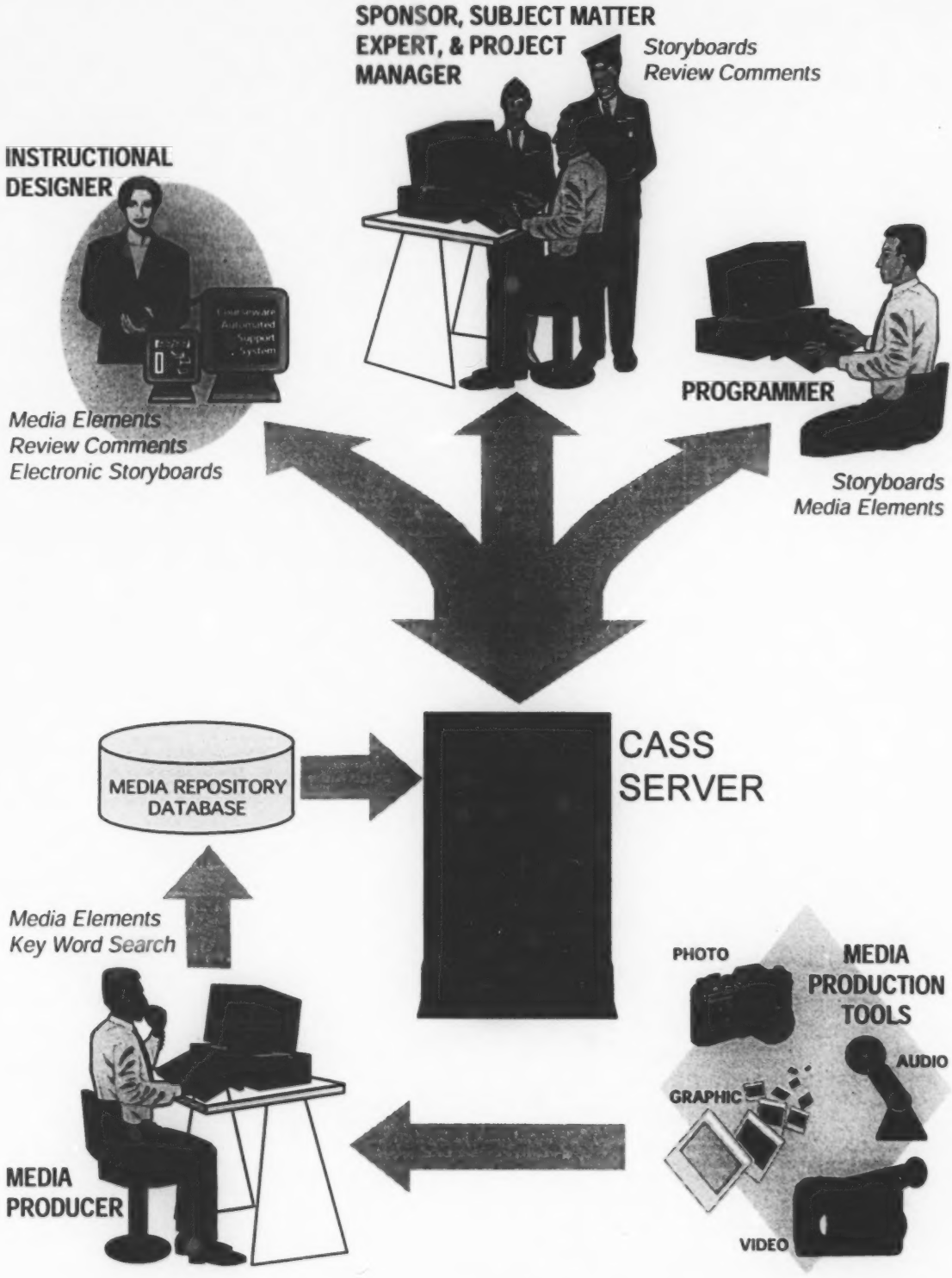

Figure 1. ICW Development Using the Automated System

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- "Find" media elements by browsing in a repository of visual or audio elements, then refine the search by looking at the visual element or listening to the audio element. When a media element is selected, it becomes attached to the storyboard and can be reviewed on the storyboard page. In some cases, visual and/or audio elements will be loaded into the multimedia database at the start of the project. For example, if the subject is maintenance training, it is very likely that before the designers begin developing storyboards, visual elements of all the equipment components would be entered into the multimedia database. Much time would be saved by not having to describe objects when the actual photograph or video clip can be entered.

In some cases it may be advantageous to obtain, digitize, and enter visual media elements into the system before any storyboarding is done. In this way, individual designers can see what the equipment actually looks like rather than having to refer to poor-quality visuals in technical manuals as they develop a lesson. They can immediately "attach" a media element to the storyboard frame if the visual is appropriate, or they can annotate the visual, explaining what changes need to be made to be useful for the storyboard frame.

Reviewers

Reviewers of ICW may be customers, subject matter experts, and managers. In some cases the project may call for subject matter experts and clients to review the electronic storyboards twice. The first review of the electronic storyboards is accomplished when the media elements are descriptions or rough drawings. In this way, they can ensure that the correct media elements will be produced. The second review is completed when the digitized media elements are "attached" to each electronic storyboard page. Reviewers can see the media elements before the whole lesson is actually programmed. With Web-based access, reviewers can review the media elements as they become available. The reviewers can add comments to any storyboard frame.

ICW Program Manager

The ICW program manager receives reports on percentage of work completed using the following parameters: percentage of total storyboards completed by the designers, lessons completed, media elements completed, and approvals received.

Media Producer/Media Database Producer

The producer of the visual and audio media elements uses reports generated by the system, such as shot lists, narrative scripts, and rough drawings, to produce the media elements. When the media elements are completed, the media database producer digitizes them and enters them in the database/media repository. Keyword descriptions are entered to help designers find media elements that are already in the system.

ICW Programmer

The multimedia ICW programmer, who uses either special-purpose authoring tools or general-purpose programming languages to author ICW, can print programming notes or open the system in a window, while programming the lesson. The programmer can import digitized media elements from the multimedia database into the lesson since all media elements are saved as files.

HOW THE AUTOMATED SYSTEM WAS DEVELOPED

The system definition involved the following steps: (1) capture the concept of operations, (2) document a concise set of requirements, (3) develop a preliminary database architecture, (4) select appropriate system hardware, (5) design the network architecture, and (6) select COTS software. Of primary importance during these tasks was the determination of the proper combination of hardware, software and network architecture for the system. The decision was made to use open, Internet-based standards instead of proprietary, Windows-only solutions. This decision to use "open standards" is based on the belief that the raw power of Internet technologies such as Web servers, Web browsers, Java and client/server databases more than makes up for the problems to be expected using such emerging technologies.

The system design may be summarized as a partitioned client/server JavaScript system. The system concentrates almost all of the computation and database work on the server. The small amount of code that must run on the client's

machines is loaded into the user's Web browser by the system while it is running. This happens transparently to system users. The system is able to maintain its high level of platform independence because the part of the application running on a client computer is written in JavaScript, which is supported by most major Web browsers under most operating systems.

Network Architecture

The network architecture is a wide area network (WAN) which uses standard Internet protocols. This allows access to the system from remote sites connected to the Internet. Connections from networks other than the assigned members of the development team are disallowed unless specifically enabled. Internet-based networking allows the system to easily support remote users and leaves the door open for supporting multiple types of client systems in the future. In many image-intensive systems, Macintosh or UNIX computers are used, due to their ease of use (Macintosh) and power for editing graphic images and digital video content (UNIX). Another reason for the selection of an Internet-based network architecture was that it could easily mature into a distributed data repository instead of a centralized data repository. The database information needed to track and manage courseware development efforts will always reside in a single database system somewhere on the network, but the actual media files (images, digital video, etc.) might be stored in a distributed manner on the other computers being used to produce an ICW product. The availability of free or very inexpensive Web servers for most PC platforms makes this a real possibility. The major benefit of this approach is that allowing a user to store media files on a local computer provides improved performance and lower network traffic.

Software Used to Develop the System

The system is written in an enhanced version of the JavaScript programming language with commercial off-the-shelf (COTS) "add-ons" to provide hooks to a Web server, hooks into one or more database subsystems, and hooks into the operating system, Web server, and application security subsystems. The system uses the following commercial software products:

- Netscape "FastTrack" Web server, Microsoft "FTP Server" (included with NT)
- Borland International "Intrabuilder" development system for client/server JavaScript development
- Borland International "Borland Database Engine" to provide server-side SQL database support (included with Intrabuilder)

Database Architecture

The system is built on a shared multimedia database that underlies special-purpose user-interface screens that support users in the paradigms in which they are used to working, such as the electronic storyboard for instructional designers, reviewers, and programmers; reports for media producers containing shot lists, narrative scripts, etc.; management reports; and forms for entry of information into the multimedia database.

The database architecture selected for the system is a hybrid database/file repository scheme in which database records *reference* actual media element files that reside in *data repositories*. A data repository is simply a specification of a particular directory. Currently, all system data repositories reside on the system server. Support for data repositories on other computers on the local network is one of many planned enhancements to the system.

The system uses local Paradox or Dbase file formats, which provides good performance without the need to license additional database software. It is unnecessary to use a conventional relational database system because the Borland Database Engine supports most major client/server database systems, including Microsoft SQL server, Oracle, and Borland InterBase. Local database file formats such as Access, Paradox, and Dbase are also supported, as is access to ODBC databases from the server. By using standard SQL queries in the system source code, the system could very easily be adapted to support any of the database systems above. For a larger application, a dedicated database server running Oracle or MS-SQL server could be added to the network and the same SQL statements would still work. For even larger user communities the system software may be distributed across multiple system servers.

Security

Security in the automated system is handled by user IDs and passwords combined with the use of Intranet restrictions. The Intranet restrictions mean that only IP addresses within the company domain are allowed to connect to the system server, and that the local network that the system runs on is protected against forged IP packets that claim to be part of the local network but that actually originate from outside. Because the system is built on top of Web server technology, it is possible to use the secure Web server technology being offered by both Netscape and Microsoft. An enhancement to the system is planned which will provide an additional layer of security, based on digital certificate encryption technology that effectively scrambles all communication between the system Web server and a user's Web browser.

Hardware/Software Required to Use the Automated System

The system does not require that any special software be installed on the user's computer. Users access the system using a standard Internet Web browser such as Netscape Navigator or Microsoft Internet Explorer. Users with Windows, Windows 95, Windows NT, OS/2, Macintosh, or UNIX computers can access and use the system. All system user-interface "forms," such as the electronic storyboard tool, present themselves as Web pages to system users. These forms use standard Hypertext Markup Language (HTML)-based Web user interface mechanisms such as buttons to click on, text entry areas, and drop-down lists. Users navigate within the system by simply clicking on buttons to open and close user-interface forms. The server requires a PC with Microsoft Windows NT (workstation or server).

ENHANCING THE CAPABILITIES OF THE AUTOMATED SYSTEM

Preliminary use of the system resulted in identification of the following additional features which will make the system more useful for ICW development, especially large ICW development efforts.

- A distributed media repository to replace the current database structure. This will allow designers to browse the entire media repository, while at the same time they will have rapid access to the images and sound files they are most likely to use. For example, images related to maintenance would exist on the server of a designer of maintenance training, while images related to operation would exist on the server of a designer of operator training. However, both designers would be able to access all images in the media repository.

- A full-text search capability to facilitate designers who are searching in the media repository for desired media elements.

- An encryption capability to allow safe access to the system from geographically disbursed customers, managers, and subject matter experts to review and sign off on the ICW at various stages in its development.

- A capability to store and play executables that will allow the system to treat simulations and animations, which are written in standard programming languages, like any other digital media element.

- Tools that will make it easier to load completed media elements into the media repository and which will facilitate generation and copying of media repositories.

- Teaming tools that will further facilitate the sharing of information, such as a whiteboard and internal e-mail.

- Additional user interfaces and reports generated by the system, as well as enhancements to existing user interfaces and reports, which will be developed, based on recommendations from managers, media professionals, instructional designers, and clients using the system.

- An icon-based system for creating and accessing courses, lessons, and frames, like those used in various authoring systems.

Further investigation will be conducted into the feasibility of developing the capability to port the overall course structure defined in the system

software into one or more courseware authoring tools and to provide direct access to the system database tables from within one or more commercial ICW authoring systems. It is believed that these features will save additional programming time as well as ensure that the desired structure is properly captured in the final ICW product.

TIME AND COST SAVINGS USING THE AUTOMATED SYSTEM

A comparison of the time required to develop one hour of ICW using the automated approach and the traditional approach was performed. The time data for the traditional approach is based on historical data from a recent project. The time data for the automated approach is based on a development effort in which the automated system was used. In this example, all types of media were produced for the lesson. The ICW developed is PC-based using software-only digital video and COTS authoring graphics/software. The times listed in Table 1 represent the combined total labor hours for all staff members participating in the project for each task. A description of the reason for the time savings attributed to using the automated system is shown in italics.

In this example, the time was reduced by approximately 30 percent when the automated system was used. We expect that the time ratios between traditional and automated approaches will widen as more hours of ICW are produced. For example, if 200 hours of ICW are being developed, the time to prepare, deliver, receive comments, revise both the storyboard and the actual lessons, and manage the overall effort will increase with the traditional approach and decrease with the automated approach. It is estimated that the cost and time for 200 hours could be reduced by up to 50 percent if the automated system is used.

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Table 1. ICW Project Development Using Traditional and Automated Approaches

ICW TASKS	APPROACHES	
	TRADITIONAL	AUTOMATED
1. Analyze training content	24	24
2. Develop instructional "treatment" plan	24	24
3. Prepare storyboard *The electronic storyboard makes it easier to enter information and make changes as the designer is "evolving" the lesson. No more "cut and paste," "white out," or Xeroxing.*	40	20
4. Deliver storyboard *Traditionally, four hours is the time required to Xerox, write the delivery letter, package, and mail. Although not labor hours, additional time is also required for the customer to receive the storyboards through the postal service.*	4	0
5. Receive sponsor review comments on storyboard *Usually 5 days are required to receive comments via postal service; 2 hours are required to unpack and make clerical configuration control entries.*	2	0
6. Revise storyboard *In paper format, revisions require fixing graphics, editing text, Xeroxing, re-mailing, etc.*	8	2
7. Receive approval of storyboard *With the traditional approach, sponsors may take months to send approval letters. With the automated system, the reviewer can review and approve, using a secure code.*	2	0
8. Produce media • Record audio • Develop graphics and animation • Record motion video • Take still photographs *Redundancy of effort (e.g., more than one person producing the same media element) is eliminated. Audio exists in files in the system, which makes it easier for the developer to manipulate.*	 24 40 8 8	 4 30 8 8
9. Program lesson using authoring system *Programming effort is reduced because all media elements are stored in the resource database.*	40	20
10. Deliver lesson	2	2
11. Receive sponsor comments	8	8
12. Revise lesson	8	8
13. Conduct evaluation using students	8	8
14. Revise lesson	2	2
15. Deliver final lesson	2	2
16. Overall management *With the automated system, management reports and on-line review capability decrease management time*	4	0.5
TOTAL	**258**	**170.5**

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